TITLE OF THE INVENTION

IMAGE FORMING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an image forming apparatus, such as a copying machine or a printer, provided with a fixing unit which fixes a developer image on paper.

2. Description of the Related Art

In recent years, in a fixing unit installed in a copying machine using electrophotographic processes, a method using the heat generation of metal by electromagnetic induction has been put to practical use.

One known fixing unit using induction heating is such that, for example, the magnetic flux leaking from the induction coil provided outside the fixing roller is suppressed by a shield member and the heat dissipation of the induction coil is enhanced (Jpn. Pat. Appln. KOKAI Publication No. 2001-313162).

Another known induction heating fixing unit with a exciting coil outside the rotating body is such that the arrangement of a magnetic material on the opposite side of the rotating body of the exciting coil not only increases the heat generation efficiency but also prevents the magnetic field produced from the exciting coil from leaking to the adjoining parts (Jpn. Pat.

Appln. KOKAI Publication No. 11-297462).

A further known induction heating fixing unit is such that an induction heating member, a film member for moving the heating member, and an exciting coil fixing member have a ferromagnetic, high-resistivity shield member, thereby preventing electromagnetic noise leaks (Jpn. Pat. Appln. KOKAI Publication No. 9-16006).

Preventing the high-frequency magnetic field generated from the coil from leaking to the outside of the fixing unit prevents the faulty operation of the other devices in the apparatus, including an optionally installed printer controller and FAX controller.

In addition, even when a magnetic field differing in intensity is generated according to the operation mode, the effect of the magnetic field on the other devices in the apparatus is reduced to a minimum.

BRIEF SUMMARY OF THE INVENTION

According to an aspect of the present invention, there is provided an image forming apparatus comprising: a heating member which includes a conductive member containing a coil for, when supplied with a voltage and current of a specific frequency, producing a magnetic field of a specific magnetic field intensity and generating heat by the magnetic field supplied from the coil; a magnetic field attenuating mechanism which is capable of attenuating the magnetic

field intensity of the magnetic field passing through

the mechanism; and at least one magnetic field

attenuating mechanism unit which is provided between

a specific magnetic field intensity measuring point and

5   the coil.

According to another aspect of the present

invention, there is provided an image forming apparatus

comprising: a heating member which includes a

conductive member having on its outside a coil for,

10   when being supplied with a voltage and current of

a specific frequency, producing a magnetic field of

a specific magnetic field intensity and generating

heat by the magnetic field supplied from the coil;

a magnetic field attenuating mechanism which is capable

15   of attenuating the magnetic field intensity of the

magnetic field passing through the mechanism; and at

least one unit of the magnetic field attenuating

mechanism which is provided between a specific magnetic

field intensity measuring point and the coil.

20   Additional objects and advantages of the invention

will be set forth in the description which follows, and

in part will be obvious from the description, or may be

learned by practice of the invention. The objects and

advantages of the invention may be realized and

25   obtained by means of the instrumentalities and

combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.

FIG. 1 is a schematic diagram to help explain an image forming apparatus to which an embodiment of the present invention is applicable;

FIG. 2 is a schematic diagram to help explain a fixing unit installed in the image forming apparatus of FIG. 1;

FIG. 3 is a schematic diagram to help explain an example of the arrangement of an exciting coil in the fixing unit of FIG. 2;

FIG. 4 is a schematic diagram to help explain the fixing unit shown in FIGS. 2 and 3 and the control system of the image forming apparatus of FIG. 1;

FIG. 5 is a schematic diagram to help explain an example of the fixing unit applicable to the image forming apparatus of FIG. 1;

FIG. 6 is a reference diagram to help explain a first characteristic of a shield plate applicable to a fixing unit of the present invention;

FIG. 7 is a reference diagram to help explain a second characteristic of the shield plate applicable

to the fixing unit of the present invention;

FIG. 8 is a reference diagram to help explain
a third characteristic of the shield plate applicable
to the fixing unit of the present invention;

FIG. 9 is a schematic diagram to help explain
another example of the fixing unit applicable to the
image forming apparatus of FIG. 1; and

FIG. 10 is a reference diagram to help explain
leakage magnetic flux intensity when a shield plate
applicable to the fixing unit of the present invention
is not used.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, referring to the accompanying
drawings, an image forming apparatus to which an
embodiment of the present invention is applied will be
explained.

As shown in FIG. 1, an image forming apparatus
(digital copying machine) 101 comprises an image
reading unit (scanner) 102 for generating an image
signal by reading an object (document) P to be read or
copied and an image forming section 103 for forming an
image on the basis of the image signal outputted from
the scanner 102. An image signal outputted from
a printer board 103b to which an interface 103a is
connected may be inputted to the image forming
section 103.

The image forming section 103 includes a fixing

unit 1, a photoreceptor drum 105, a photolithography machine 106, a developing machine 107, a sheet cassette 18, a pickup roller 109, a transport path 110, an aligning roller 111, a discharge roller 112, and a catch tray 113.

The fixing unit 1 applies heat and pressure to a sheet Q which holds a toner image, thereby setting (fixing) the melted toner image to the sheet Q. The fixing unit 1 is covered with a protective cover 201 and is therefore housed on the inside of the cover 201, which will be explained later by reference to FIG. 5.

Therefore, the sheet Q passes through the photoreceptor drum 105 and fixing unit 1 vertically in that order, thereby forming an image of the document P. The sheet Q on which the image has been formed is discharged by the discharge roller 112 to the catch tray 113 defined between the sheet cassette 108 and the scanner 102.

FIGS. 2 and 3 are schematic diagrams to help explain an example of the fixing unit used in the image forming apparatus of FIG. 1.

FIG. 2 is a schematic plan view to help explain an example of the fixing unit 1.

The fixing unit 1 includes a fixing (heating) roller 2, a press (pressure) roller 3, a pressure mechanism 4, a peeling claw 5, a temperature sensing

element 6, a cleaning member 7, a heat generation abnormality sensing element 8, a peeling claw 9, a cleaning roller 10, an exciting coil 11, a coil holder 12, and a magnetic core 13.

5   The heating roller 2 is such that a metal hollow cylinder conductive member with a thickness of about 1 mm, preferably about 0.5 mm, is held in roller form. The conductive member of the heating roller 2 may be made of iron, stainless steel, nickel, aluminum,

10   an alloy of stainless steel and aluminum, or the like. On the surface of the heating roller 2, a separate layer (not shown) is formed by depositing fluorocarbon resin, such as tetrafluoroethylene resin, to a specific thickness.

15   In the embodiment, an electroformed belt made of nickel of a thickness of h2 = 0.04 mm is used as the conductive member of the heating roller 2. A roller with an outside diameter of 40 mm is used for the heating roller 2 and fixing roller 3.

20   The pressure roller 3 is an elastic roller which is such that a rotation axis with a specific diameter is covered with silicone rubber, fluoric rubber, or the like of a specific thickness.

The pressure mechanism 4 is pressed towards the
25   longitudinal axis of the heating roller 2 at a specific pressure. The pressure roller 3 is kept almost in parallel with the longitudinal axis of the heating

roller 2.

As a result, a specific nip is formed between the two rollers.

The heat generation abnormality sensing element 8, which is, for example, a thermostat, senses a heat generation abnormality of the surface temperature of the heating roller 2 rising abnormally. When heat generation abnormality has occurred, the heat generation abnormality sensing element 8 is used to cut off the electric power supplied to the heating coil (exciting coil) explained below.

The order in which the temperature sensing elements 6a, 6b, cleaning member 7, and heat generation abnormality sensing element 8 are arranged and their locations is not limited to the order and locations shown in FIG. 2.

The peeling claw 9 for peeling the sheet Q from the pressure roller 3 and the cleaning roller 10 for removing toner adhered to the surface of the pressure roller 3 are provided on the circumference of the pressure roller 3.

The heating roller 2 includes the exciting coil 11 for supplying a specific magnetic field to the heating roller 2 composed of a conductive member, a coil holder 12 for holding the exciting coil 11, and the magnetic core 13 for increasing the flux density of the magnetic field generated from the exciting coil 11 usable to

cause the heating roller 2 to generate heat.

The coil holder 12 has high heat resistance and high insulation. For example, the coil holder is made of engineering plastic, ceramic, PEEK (polyether ether ketone) material, phenol material, unsaturated polyester, or the like.

The magnetic core 13 is made mainly of a material with low losses at high frequencies, such as a dust core. The exciting coil 11 may be an air-core coil without a magnetic core material.

FIG. 3 is a schematic diagram of the fixing unit 1 of FIG. 2 viewed from the direction shown by the arrow R, with a part of the cover broken away.

The exciting coil 11 is composed of a first coil 11a located almost in the middle in the longitudinal direction of the heating roller 2, and a second coil 11b and a third coil 11c located near at both ends in the longitudinal direction of the heating roller 2, that is, at both ends of the first coil 11a.

The first coil 11a (center coil) is so formed that it has such a length as, when, for example, a A4-size sheet is conveyed in such a manner that its short side is in parallel with the longitudinal axis of the heating roller 2, enables the width of the sheet contacting the outer circumferential surface of the roller 2 to be heated.

The second and third coils 11b, 11c (end coils)

are a single coil electrically and connected in series.
When they are arranged in line with the first coil 11a
as shown in FIG. 3, the longitudinal length of them is
a little longer than the short side of a A3-size sheet.

5   The first, second, and third coils 11a, 11b, and
11c are made of a wire material whose cross-sectional
area is equivalent to, for example, a 1-mm copper
material. A stranded wire formed by stranding a
plurality of thin wire materials with no insulating
10   film, a litz wire formed by stranding a specific number
of wire materials each covered with insulating
material, or the like may be used as the wire material.
Each of the coils 11a, 11b, and 11c can be formed by an
arbitrary winding method. They are wound around the
15   coil holder 12.

A voltage and current of a specific resonance
frequency are supplied to each coil. The coil then
applies a magnetic field of a specific magnetic field
intensity to a specific part of the heating roller 2,
20   thereby generating a magnetic flux and an eddy current
in the heating roller 2. The eddy current and heating
roller resistance produce Joule heat, thereby heating
the heating roller 2.

Therefore, the second and third coils 11b, 11c are
25   helpful in heating the vicinities of both ends of the
heating roller 2, whereas the first coil 11a can heat
the middle in the longitudinal direction of the heating

roller 2.

The center coil and end coils may be divided, for example, almost in the middle of the heating roller 2 into two. Alternatively, for example, when a coil (not shown) is provided for the pressure roller 3, the first coil 11a (center coil) may be provided on the heating roller 2 side and the second and third coils 11b, 11c (end coils) may be provided on the pressure roller 3 side.

A wire material with a specific cross-sectional area is used for the first, second, and third coils 11a, 11b, and 11c. Each of the first, second and third coils has a specific number of turns so as to resonate at its inherent resonance frequency, thereby maximizing its resistance value. They are designed to produce almost the same outputs. The output of each of the coils produces a magnetic flux capable of producing an eddy current to cause the heating roller 2 (or pressure roller 3) to generate heat. The output of the coils is managed by controlling the power supplied to the coils.

FIG. 4 is a diagram to help explain a driving circuit for operating the fixing unit 1 shown in FIGS. 2 and 3 and a control circuit for operating the image forming apparatus into which the fixing unit 1 is incorporated.

The heating roller 2 of the fixing unit 1 houses the exciting coil 1 (coils 11a, 11b, 11c) for producing

an eddy current in the conductive material of the
heating roller 2 as described above and thereby
generating heat.

Connected to the exciting coil 11 is an exciting
5   unit 31 for supplying high-frequency outputs of
a specific frequency (current and voltage) to each coil
of the exciting coil 11.

The exciting unit 31 includes a switching circuit
32 capable of outputting high-frequency outputs to be
10   supplied to the individual coils 11a, 11b, 11c and
a driving circuit 33 for inputting a specific control
signal (the number of times of switching) to the
switching circuit 32 to supply a specific output to the
respective coils.

15   The switching circuit 32 is capable of, for
example, connecting all of the coils 11a, 11b, 11c in
series, or connecting the coils 11b, 11c in series and
then connecting the resulting series connection in
parallel with the coil 11a, or connecting all of the
20   coils 11a, 11b, 11c in parallel. That is, the
switching circuit 32 also functions as a selector unit
capable of setting a series connection or a parallel
connection between the individual coils 11a, 11b, 11c.

A direct-current voltage obtained by rectifying
25   a received commercial power alternating voltage with
a rectifier (not shown) is supplied via the driving
circuit 33 to the switching circuit 32.

At this time, the driving circuit 33 instructs the switching circuit 32 of which of the high-frequency outputs is to be outputted by the switching circuit 32, or the time that the switching elements (not shown) are to be turned on for the respective coils 11a, 11b, 11c to output the coil outputs, specific heating power, or the number of times (driving frequency) the switching element is turned on during a unit time.

In the embodiment, the driving circuit 33 instructs the switching circuit 32 of a first frequency f1 to be supplied to the coil 11a and a second frequency f2 to be supplied to the coil 11b. In other words, the magnitude of the magnetic flux, or the heating power, outputted from each coil to produce an eddy current in the heating roller 2 to raise the temperature of the heating roller 2 can be set to an arbitrary magnitude by controlling the driving circuit 33 to change the outputs from the switching circuit 32 to the respective coils.

The heating power is generally managed in values in the form of the amount of power consumed by each coil. Hereinafter, explanation will be given regarding the coil output (power consumption) of each coil just as an electric power inputted to a coil and the frequency of the power consumption as the using frequency.

The electric power supplied from the rectifying

circuit to an arbitrary one or all of the coils is
continually monitored by an electric power sensing
circuit 41 provided in a specific place, such as
between the rectifying circuit and the input terminal
5   of a commercial power supply, between the rectifying
circuit and the driving circuit 33, or between the
driving circuit 33 and the switching circuit 32.

The result of the monitoring by the electric power
sensing circuit 41 is fed back to the driving circuit
10   33 with a specific timing. To make it possible to
sense the burnout or the like of the driving circuit
33, the output of the electric power sensing circuit 41
is also inputted to a main control unit 151 on the
image forming section 103 side.

15   The main control unit 151 is connected to a motor
driving circuit 153.

The motor driving circuit 153 is connected to
a main motor 121 for supplying driving force to
a specific member of the image forming section 103,
20   such as the photoreceptor drum 105, and the fuser motor
123 for rotating the heating roller 2.

In a case where electric power of a specific
frequency is supplied to a first coil and a second coil
differing in a coil constant, such as inductance L (the
25   inductance of the second coil is lower than that of the
first coil), when an independent switching circuit is
provided, an attempt to control the output of the

second coil in the same range as that of the first coil
requires the second coil to have the frequency range of
about 30 kHz to 40 kHz, provided that, for example, the
frequency range required to control the output of the
5   first coil in the range of 1 kW to 600 W is from 20 kHZ
to 30 kHz.

That is, when the coil outputs of the coils
differing in inductance are changed, operating the
individual coils independently results in a small
10   variation in the frequency.

In contrast, in a case where the first coil with
a specific inductance and the second coil with a lower
inductance than that of the first coil are connected to
a single switching circuit and electric power of a
15   specific frequency is supplied, for example, when the
output of the first coil is 900 W and the output of the
second coil is 1.1 kW at a frequency of 20 kHz, the
output of the first oil is changed to 500 W and the
output of the second coil is changed to about 0.9 kW at
20   a frequency of 30 kHz. In addition, when the frequency
is changed to 40 kHz, the output of the first coil is
lowered to about 200 W, whereas the output of the
second coil is kept at about 500 W.

Next, the relationship between the frequency of
25   electric power supplied to each coil and the coil
output will be explained.

For example, electric power supplied to each of

the coils 11a, 11b, 11c can be changed in the range of, for example, 700 W to 1.5 kW arbitrarily in terms of the amount of power consumed by the coil. As is generally known, the amount of current flowing in any one of the coils 11a, 11b, 11c of the exciting coil 11 is determined by setting a frequency applied to the coil, an impedance, and so forth.

For example, in a case where electric power differing only in frequency is supplied, even when the current value is 10 mA, the inductance and pure resistance are changed as follows: inductance L = 24.6 µH, pure resistance R = 1,2 Ω at 25 kHz, inductance L = 18.69 µH, pure resistance R = 3.5 Ω at 100 kHz, and inductance L = 15.1 µH, pure resistance R = 4,9 Ω at 1 MHz. Therefore, the higher the frequency, the larger the impedance.

FIG. 5 is a view of the peripheral part of the fixing unit provided in the image forming apparatus of FIG. 1, showing the positional relationship between the outside wall of the image forming apparatus 101 and the fixing unit.

As shown in FIG. 5, the fixing unit 1 is provided inside the image forming apparatus 101, that is, inside protective covers 201a, 201b. Around the fixing unit 1, for example, an optional specific circuit 203 is provided.

The first magnetic field intensity measuring point

is within the protective cover 201a. The first
magnetic field intensity measuring point P1 is
a specific point within the protective cover 201a that
is the closest to the exciting coil 11 and has the
5   shortest distance d1 (including the thickness of the
protective cover 201a) to the exciting coil 11.

The second magnetic field measuring point P2 is
within the circuit 203. The second magnetic field
intensity measuring point P2 is a specific point which
10   is the closest to the exciting coil 11 and has the
shortest distance d2, within the circuit 203.

Between the first magnetic field intensity
measuring point P1 and the exciting coil 11, there are
provided magnetic field attenuating mechanisms (shield
15   plates) 202a, 202b capable of attenuating the intensity
of the magnetic field passing between them to
a specific intensity or less. In addition, between the
second magnetic field intensity measuring point P2 and
the exciting coil 11, the shield plate 202a is
20   provided. The magnetic field intensity attenuating
mechanisms may be not only constructed from a plurality
of members but also formed integrally. The shield
plates 202s, 202b are represented simply as shield
plate 202 in the explanation below.

25   That is, the shield plate 202 is provided between
the exciting coil 11 and the specific points in
the image forming apparatus 101 or on its surface, such

as the first and second magnetic field intensity points P1, P2.

The shield plate 202 has a minimum distance of Xmin and a maximum distance of Xmax from the exciting coil 11.

(1) The shield plate 202 has a first characteristic determined by the distance from the exciting coil 11. The shield plate 202 is provided in a specific position in the distance range of Xmax to Xmin (mm) from the exciting coil 11 of the fixing unit 1 explained below.

(2) The shield plate 202, which has a second characteristic determined by the skin depth of the conductor, is made of a specific material explained below.

(3) The shield plate 202, which has a third characteristic determined by the frequency of the voltage and current supplied to the exciting coil 11 and the skin depth of the conductor used, has a specific thickness explained below.

As determined in "Radio Wave Protection Standard" or a public level standard known in "International Committee for Nonionizing Radiation Protection (ICNIRP)," when a frequency of f (kHz) in the range of $0.8 < f < 150$ is used, the application of a magnetic field with a magnetic field intensity of 6.25 μT or more to a circuit or the like can cause a malfunction

in the circuit. Therefore, when a circuit is provided
in the vicinity of a magnetic-field-generating circuit,
the magnetic field intensity applied to the circuit has
to be equal to or lower than 6.25 µT.

5   Therefore, the exciting coil 11 has to be provided
in such a position as has a magnetic field intensity of
6.25 µT or less at least at one of the first and second
magnetic field intensity measuring points P1, P2 as
a result of the intensity of the generated magnetic
10   field being limited when passing through.

Since the catch tray 113 is formed on the left
side of the protective cover 201b, the effect of the
magnetic field need not be taken into account. The
protective covers 201a, 201b constitute the protective
15   cover 201 of the image forming apparatus 101. Although
they are divided and indicated by reference numerals
for the sake of explanation, they may be formed
integrally out of the same material.

(1) An example of the position where the shield
20   plate 202 is provided will be explained by reference to
FIG. 6.

FIG. 6 shows the relationship between the distance
X1 (mm) between a specific point on the shield plate
202 and the exciting coil 11 and leakage magnetic field
25   attenuation ratio Y1, with the abscissa axis as
distance X1 and the ordinate axis as leakage magnetic
field attenuation ratio Y1. The distance X1 is the

maximum distance Xmax in, for example, FIG. 5.

The leakage magnetic field attenuation ratio Y1 is the ratio of magnetic fields capable of passing through the shield plate 202 and attenuating. The leakage magnetic field attenuation ratio Y1 is defined as the value obtained by dividing the intensity of a magnetic field passed through the shield plate 202 when the shield plate 202 is used by the magnetic field intensity at the surface of the protective cover 201a when the shield plate 202 is not used.

Since the magnetic field intensity is inversely proportional to the square of the distance, if the minimum distance from the surface of the exciting coil 11 to the first magnetic field intensity measuring point P1 is d1, the distance from the first magnetic field intensity measuring point P1 to the measuring instrument is D1, and the magnetic field intensity measured by the measuring instrument is T1, the magnetic field intensity t1 at the first magnetic field intensity measuring point P1 is expressed as:

$$t1 = \frac{T1 \ (D1 + d1)^2}{d1^2} \qquad \cdots (equation\ 1)$$

As seen from FIG. 6, as the shield plate 202 is farther away from the exciting coil 11, the leakage magnetic field attenuation ratio Y1 increases. This is because the increase of the distance X1 leads to the occurrence of a leakage magnetic field due to diffraction.

Specifically, in and around a place where the distance between the shield plate 202 and the exciting coil 11 is 100 mm, the leakage magnetic field attenuation ratio Y1 is 1, which means that the shield plate 202 has not achieved the function of preventing the magnetic field from the exciting coil 11 from leaking to the opposite side beyond the shield plate 202 (or the shielding effect). In addition, for X1 = 90 mm or more, the leakage magnetic field attenuation ratio Y1 is about 0.7 or more, which means that the effect is small for the cost of providing the shield plate 202.

However, when the distance between the shield plate 202 and the exciting coil 11 is 60 mm or less, the leaking magnetic field can be limited effectively. In addition, for X1 = 80 mm or less, the leakage magnetic field attenuation ratio Y1 is about 0.35 or less and therefore the magnetic flux intensity is suppressed to about 1/3 of the magnetic flux intensity near a place with X1 = 100 mm.

Therefore, in the embodiment, it is desirable that the shield plate 202 be provided in a place whose distance X1 from the first magnetic field intensity measuring point P1 is 80 mm or less.

Since the shield plate 202 is close to the exciting coil 11, an eddy current can be generated in the metal material of the shield plate 202, and

therefore generate heat, it is desirable that the shield plate 202 be separated by a specific distance (e.g., 5 mm) or more from the exciting coil 11.

It goes without saying that the explanation of the first magnetic field intensity measuring point P1 holds true for the second magnetic field intensity measuring point P2.

(2) Next, an example of the material of which the shield plate 202 is made will be explained by reference to FIG. 7.

FIG. 7 shows the relationship between copper, aluminum, iron, and nickel core metal materials (conductors) and the skin depth at each of the frequencies used.

The skin depth is determined according to the material and the using frequency. The skin depth is defined as the distance (or the length in the thickness direction) at which the incident magnetic field is attenuated to 1/e ($\fallingdotseq$ 1/2.718).

Specifically, if the using frequency is f, the permeability of the conductor is μ, and the conductivity is σ, the skin depth δ [m] is expressed as:

$$\delta = \sqrt{\frac{1}{\pi\, f\, \mu\, \sigma}} \qquad \cdots (\text{equation 2})$$

The relationship between the metal materials and the frequencies used is shown in FIG. 7.

As seen from FIG. 7, at the same frequency used, the skin depth δ becomes greater in the order of copper < aluminum < nickel < iron. In addition, with the same metal material, the lower the frequency used,

5   the greater the skin depth δ.

The effect of reducing the passing magnetic field, that is, the shielding effect, becomes greater as the skin depth decreases.

Therefore, a greater shielding effect can be

10 expected of aluminum or copper of a smaller thickness than nickel, iron, or the like.

Aluminum or an alloy of aluminum and iron may be used, taking cost and weight factors into account.

(3) Next, an example of the thickness of the

15 shield plate 202 will be explained by reference to FIG. 8.

FIG. 8 shows the relationship between the plate thickness of the shield plate 202 and the magnetic field intensity attenuation ratio. The plate thickness

20 on the abscissa axis is represented by a multiple of the skin depth in a relative value, because of a difference in the skin effect due to the material and the frequency used.

As explained above, the skin depth is defined as

25 the distance (or the length in the thickness direction) at which the incident magnetic field is attenuated to $1/e$ ($\fallingdotseq 1/2.718$).

Therefore, the magnetic field intensity at each of the first and second magnetic field intensity measuring points P1, P2 is attenuated effectively when the generated magnetic field passes through the shield plate 202 with a specific skin depth.

As seen from FIG. 8, securing the thickness defined as five times or more the skin depth according to the material of the conductor causes the magnetic field intensity at the surface of the protective cover 201a to be attenuated efficiently.

As shown in FIGS. 2 to 5, the exciting coil 11 is provided inside the heating roller 2 made of the conductive material. That is, the conductive member as the heating roller 2 and the shield plate 202 are provided between the exciting coil 11 and the first magnetic field intensity measuring point P1 (protective cover 201a) or between the exciting coil 11 and the second magnetic field intensity measuring point P2 (circuit 203). Therefore, the conductive member of the heating roller 2 has the same shielding effect as the shield plate 202.

Accordingly, as shown in FIG. 5, if the skin depth of the shield plate 202 is δ1, its thickness is h1, and the skin depth of the conductive member of the heating roller 2 is δ2, and its thickness is h2, the following expression holds:

$$\frac{h1}{\delta 1} + \frac{h2}{\delta 2} \geqq 5 \qquad \cdots \text{(equation 3)}$$

Therefore, use of the shield plate 202 satisfying equation 3 causes the magnetic field intensity at each of the first and second magnetic field intensity measuring points P1, P2 to be attenuated efficiently.

5   Since the attenuation of the magnetic field intensity at the second magnetic field intensity measuring point P2 decreases the intensity of the magnetic field applied to the circuit 203 (including an optional device), the malfunction of the peripheral devices can

10   be improved.

When the generated magnetic field intensity is the highest, for example, when the power consumption of the coil at the time of warm-up is the largest (e.g. 1300 W), the frequency is 20 to 25 kHz.

15   As the shield plate 202 satisfying the first to third characteristics (1) to (3), it is desirable in the embodiment that (1) the shield plate be provided at a distance X1 of 80 mm or less from the surface of the exciting coil 11, that (2) the shield plate be made of

20   aluminum, and that (3) the thickness h1 be at least 0.065 mm or more. (3) the thickness h1 can be calculated by substituting the skin depth and thickness at a using frequency of 20 kHz into equation 3, since the conductive material used in the embodiment is made

25   of nickel with a thickness of h2 = 0.04 mm and the shield plate 202 is made of aluminum with a thickness of h1. As described above, since the thickness h1 of

the shield plate 202 is determined by substituting into
equation 3 the skin depth at a using frequency of
20 kHz, that is, the frequency of the power supplied to
the exciting coil to generate a magnetic field of the
highest magnetic field intensity, the magnetic field
intensity of at least one of the first and second
magnetic field intensity measuring points P1, P2 can be
made equal to or lower than 6.25 μT.

As known from "Method of checking conformance to
the Radio Wave Protection Standard (ARIBRT-11)," the
range where the effect on the human body having the
measuring instrument or the nearby metals or the like
is alleviated is such that the distance from the
measuring instrument is 20 cm or more away from every
object in the case of a radiation source of a frequency
of 300 MHz or more. While this range was being kept,
the magnetic field was measured using a Combinover
MPR-II (frequency range of 2k to 400 kHz).

Since the exciting coil 11 might generate harmonic
magnetic fields according to the frequency of the
voltage and current applied (the using frequency), it
is desirable that the frequency range of the measuring
instrument to be used be at least five times or more as
high as the using frequency.

The verification using the above-explained
magnetic field measuring method has shown that, when
the shield plate 202 which (1) was provided at

a distance X1 of 50 mm from the surface of the exciting
coil 11, (2) was made of aluminum, and (3) of
a thickness of h1 = 0.25 mm was used, the intensity of
the magnetic field leaking to the outside of the fixing
unit 1 was in such a range as had no effect on the
circuit 203.

As described above, meeting all of the first to
third characteristics (1) to (3) enables a much greater
shielding effect to be expected. It goes without
saying that fulfilling at least one of the
characteristics enables a shielding effect to be
obtained.

FIG. 9 shows another example of the induction
heating fixing unit applicable to the image forming
apparatus 101 of the present invention.

As shown in FIG. 9, a fixing unit 301 includes
a conductive film 302, a pressure roller 303,
an exciting coil 304, and a shield plate 304a.
Although not shown, the fixing unit 301 is installed in
an image forming apparatus having the same function as
that of the image forming apparatus of FIG. 1, that is,
inside an protective cover 305.

A third magnetic field intensity measuring point
P3 is within the protective cover 305. The magnetic
field intensity measuring point P3 is a specific point
which is the closest to the exciting coil 11 and has
the shortest distance d3 to the exciting coil 11

(including the thickness of the protective cover 305).

The conductive film 302, which is an endless belt made of metal, such as nickel or stainless steel of several tens of micrometers in thickness, is moved in the direction shown by the arrow by a roller member provided in a specific inside position.

The pressure roller 303 applies a specific pressure to the conductive film 302, thereby forming a nip with a specific width.

The exciting coil 304, which is provided in a specific position outside the conductive film 302, applies a specific magnetic field to the outer circumferential surface of the conductive film 302.

The shield plate 304a is provided between the exciting coil 304 and the third magnetic field intensity measuring point P3 (protective cover 405). As explained later, the shield plate 304a is composed of a conductor whose thickness is h3 and whose skin depth is δ3.

Only the part of the magnetic field generated from the exciting coil 404 which has passed through the shield plate 304a is attenuated. Therefore, the thickness and material of the shield 304a are determined by the following expression:

$$\frac{h\,3}{\delta\,3} \geqq 5 \qquad\qquad \cdots \text{(equation 4)}$$

That is, the shield 304a made of a material with

the thickness h3 and skin depth δ3 meeting expression 4
is applicable to the present invention.

For example, when aluminum is used as the material
for the shield plate 304a, it is desirable that the
thickness h3 be equal to or more than 0.089 mm, five
times the skin depth of 17.8 µm at a using frequency of
20 kHz at which the maximum magnetic field of FIG. 7 is
generated. As described above, the thickness h3 of the
shield plate 304a is determined by substituting into
equation 4 the skin depth at a using frequency of
20 kHz, or at the frequency of the power supplied to
the exciting coil to generate a magnetic field of the
maximum magnetic field intensity, which enables the
magnetic field intensity at the third magnetic field
intensity measuring point P3 to be made 6.25 µT or less
in the fixing unit being used.

An example of suppressing the leakage magnetic
field by changing the thickness of the conductive
member formed into a roller shape of the heating roller
2 in the fixing unit of FIG. 2 without the shield plate
202 will be explained by reference to FIG. 10 in
comparison with the present invention.

FIG. 10 shows the relationship between the
thickness (abscissa axis) of the conductive member of
the heating roller 2 and the magnetic field intensity
(ordinate axis) at a specific magnetic field intensity
measuring point, for example, at the surface of

the protective cover in the fixing unit surrounded
with only the protective cover of the image forming
apparatus.   A shield plate is not provided between the
fixing unit and the magnetic field intensity measuring
5   point.

Therefore, in the fixing unit using no shield
plate, the exciting coil is covered and the intensity
of the passing magnetic field is decreased using the
conductive member of the heating roller of the fixing
10   unit provided between the exciting coil and the
protective cover of the image forming apparatus.
In this way, the magnetic field intensity at the
surface of the protective cover has to be made 6.25 µT
or less.

15   That is, to reduce the leakage magnetic field
intensity to 6.25 µT or less, a conductive material
whose thickness is 0.12 mm or more must be used as
shown in FIG. 10.

However, the following problem arises: the thicker
20   the conductive member, the longer the time required
for the heating roller 2 to rise to the required
temperature.   For example, at the time of warm-up, it
is desirable that the required temperature (target
temperature) be reached within 10 seconds.   In
25   addition, to secure the required nip width, a specific
flexibility is required.   Thus, it is desirable that
the conductive member be thinner.   For example,

preferably, the conductive member is 40 to 60 µm or less in thickness.

As described above, with the present invention, providing the shield plate 202 of the specific thickness and material in the specific position prevents a magnetic field of a specific magnetic field intensity or higher from leaking to the outside, which alleviates the effect of the magnetic field on the circuits installed in the apparatus, such as the circuit 203, or optionally installed units (including a printer controller and FAX controller). The invention may be applied to apparatuses other than those explained in the above embodiments.

In addition, when the fixing protective cover 301 of the fixing unit formed integrally with the fixing unit as shown in FIGS. 2 and 3 is used, the shield plate can be made thinner, taking into account the shielding effect of the member provided between the exciting coil and the protective cover of the image forming apparatus, as explained by using equation 3. That is, the value obtained by dividing the thickness of the fixing unit protective cover by the skin depth of the constituting material is further added to the left side of equation 3. If the total of the left side is 5 or less, the expression holds.